Symbolization

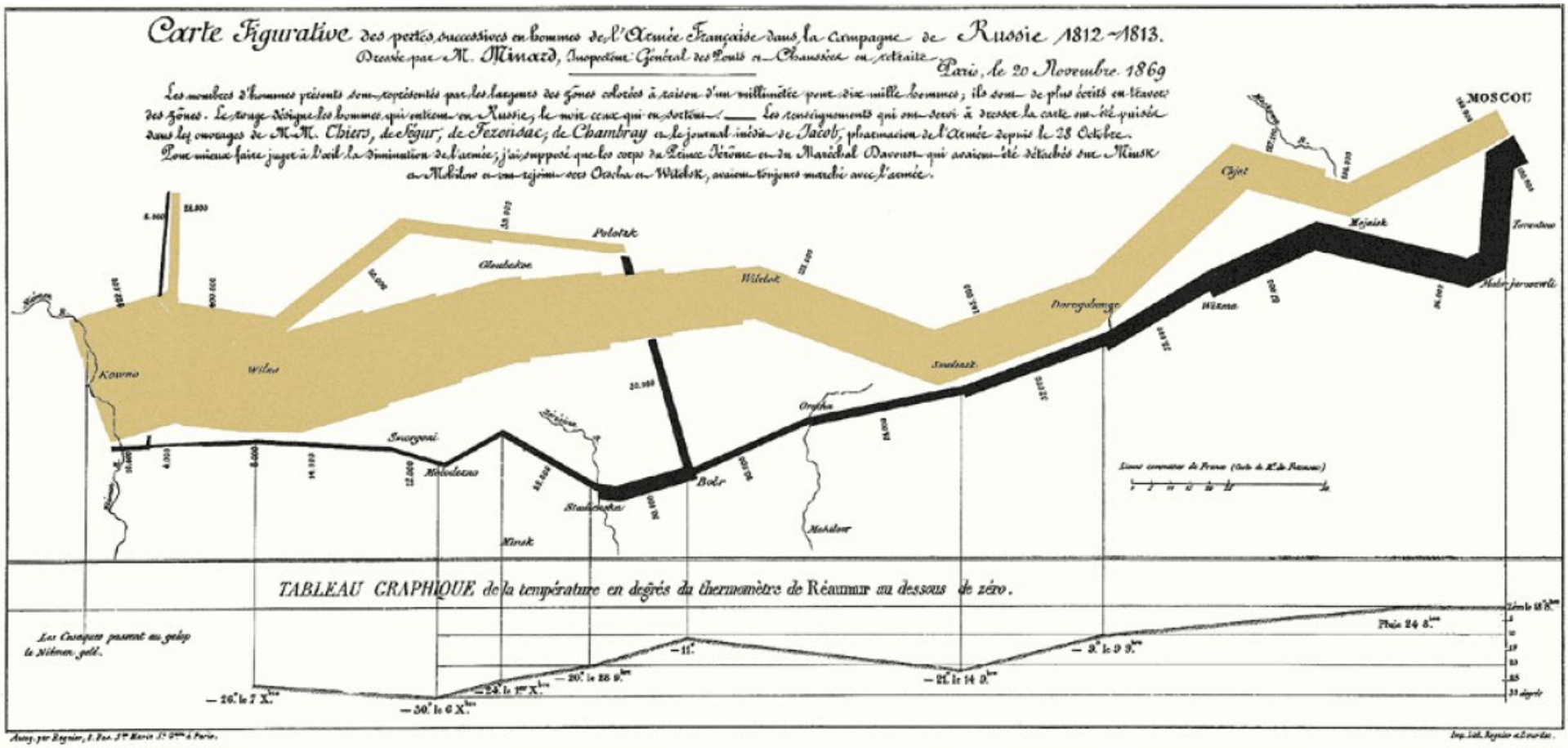
GEOG482 SP2020

Outline

- The nature of geographic phenomena, representation, and symbolization
  - How we think about phenomena
    - Discrete vs. continuous
  - How we sample phenomena
    - Random, systematic, census
  - How we measure phenomena
    - Nominal, Ordinal, Interval, Ratio measurements
  - How we represent phenomena
    - Points, lines, areas, volumes
  - How we symbolize phenomena
    - Visual variables

Matching phenomena, data, and visual variables

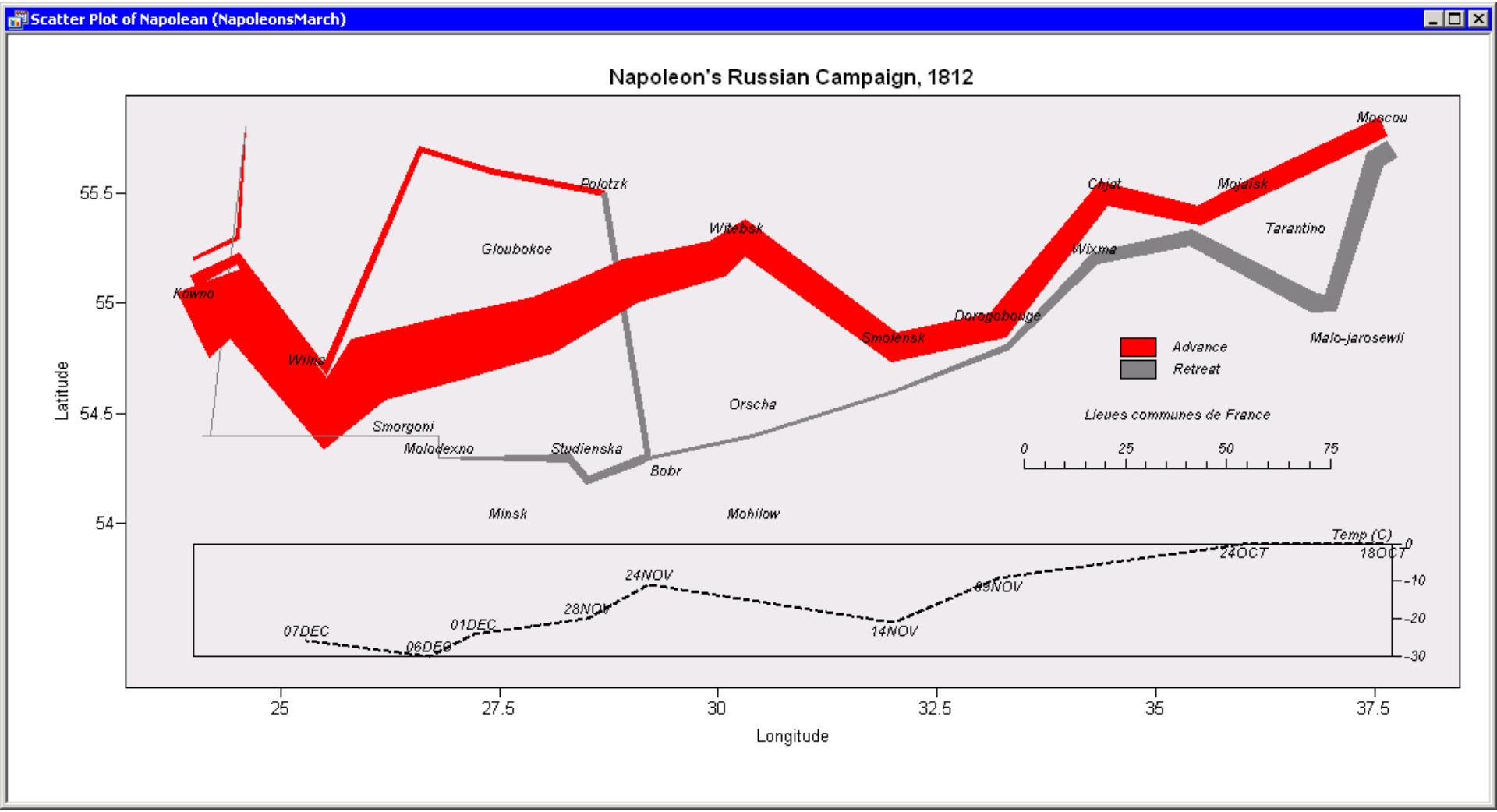
- C. J. Minard (1861). Mapping Napoleon's March in 1812



"…the single best-known statistical graphic of the nineteenth century, hailed today by statisticians, geographers, historians and the like…" (John Corbett)

Source: http://www.csiss.org/classics/content/58

Scatterplot of the Napoleon's March (how many variables?)



(image source: http://www.math.yorku.ca/SCS/Gallery/minard/Minard-IML.gif)

Group Activity: More variations

- Make 4 groups of 3-5 people
- Choose one of the variations in the link below and discuss advantages of the representation (3min.)
  - https://www.esri.com/about/newsroom/insider/catching-up-with-time/
- Share your group's thoughts

Base-map compilation
: how do we start to make maps?

- Digitization
- Data generalization
- Using external data sources

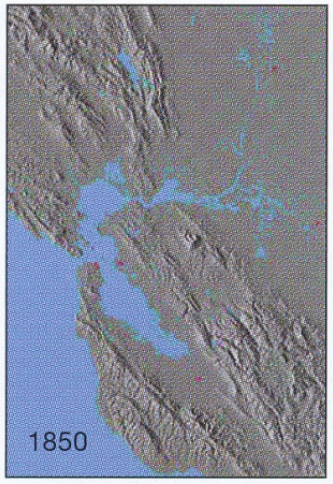
Usefulness of maps…

- Maps address key concepts in geography
  - Location, scale
  - Direction
  - Distance, interaction
  - Pattern, clustering, association
  - Regions, change
  - E.g., climate, weather, population, land-cover maps…
- Maps help answer questions related to places, regions, and human-environment interaction

Types of geometric/spatial objects

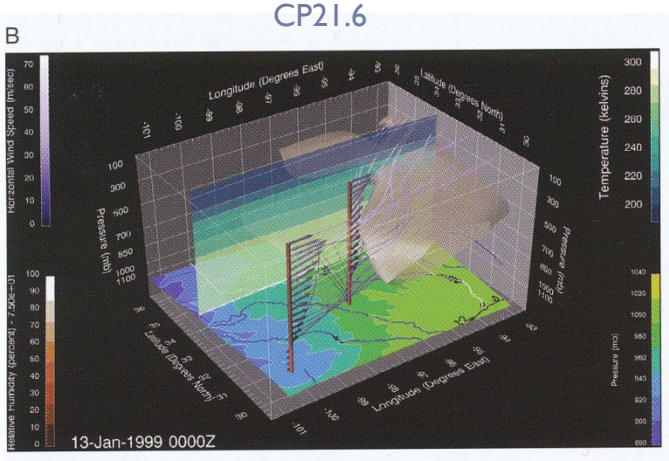
- Point: weather stations, bus stops
- Linear: country, state boundaries
- Areal: country, state
- 2.5-D: land surface elevation (CP21.3), SimCity…
- True 3-D: atmosphere, ocean (CP21.6)
- 4-D Space-time:

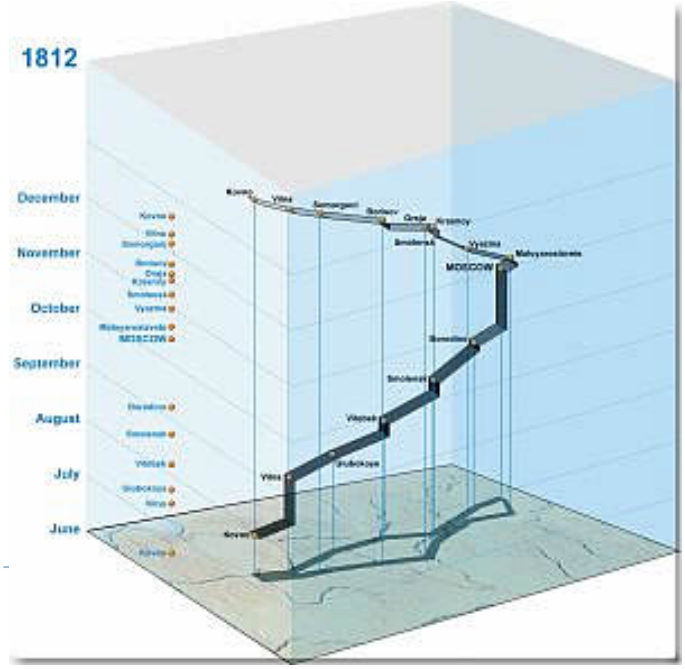
  weather systems, migration



CP21.3

CP21.6





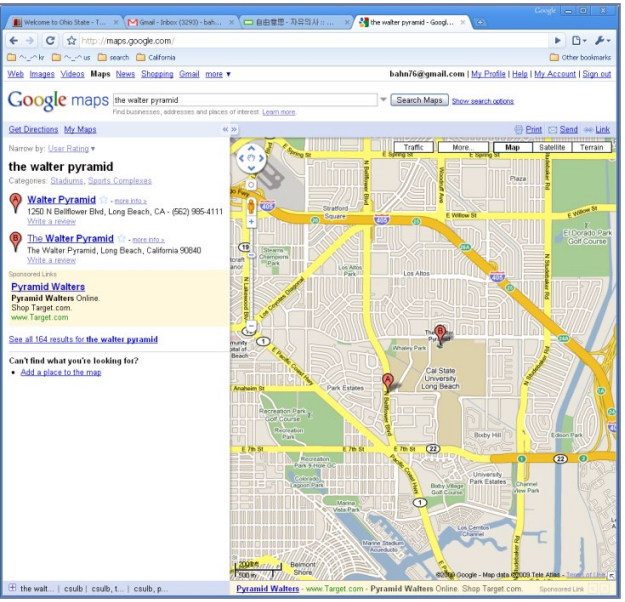
(source: Slocum et al. ; filetraffic.eu; http://www.math.yorku.ca/SCS/Gallery/minard/t-3D-napoleon-final.jpg)

Types of geometric/spatial objects (cont.)

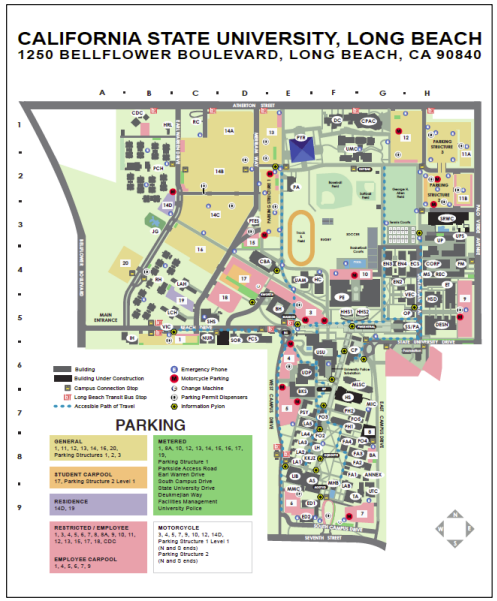
- Representation is intricately related to scale of the map
  - City (point or area?)
  - Road (line or area?)
  - Lake (area or volume?)
  - River (line, area, volume?)
  - …and dimensions?

Spatial dimensionality

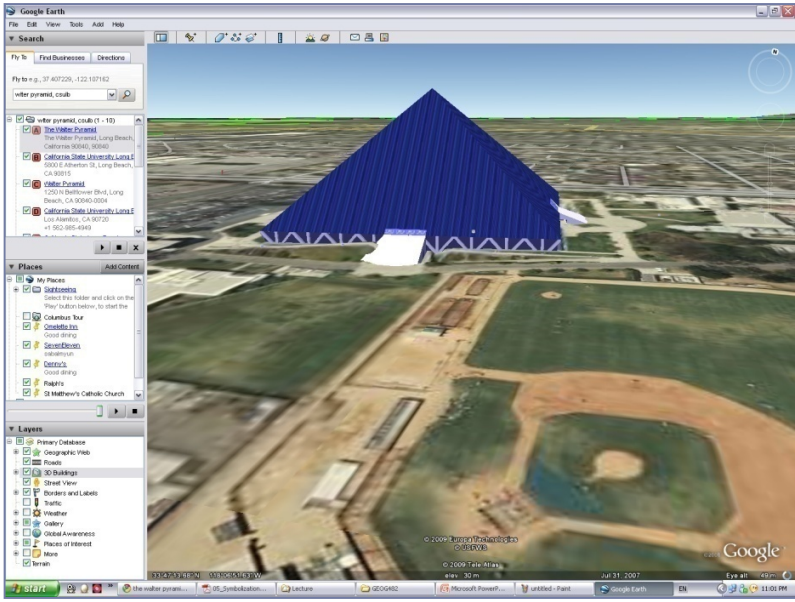
- How to represent the Pyramid at CSULB?



Source: Google maps



CSULB Campus Map



Google Earth

The important thing is not to get too hung up on the scheme but focus on what to *do* with your data

Spatial views of geographic phenomena

- First, how do we think about space?
  - Is the world made up of things with a location such as buildings, cities, mountains, or rivers?
    – **The discrete view**

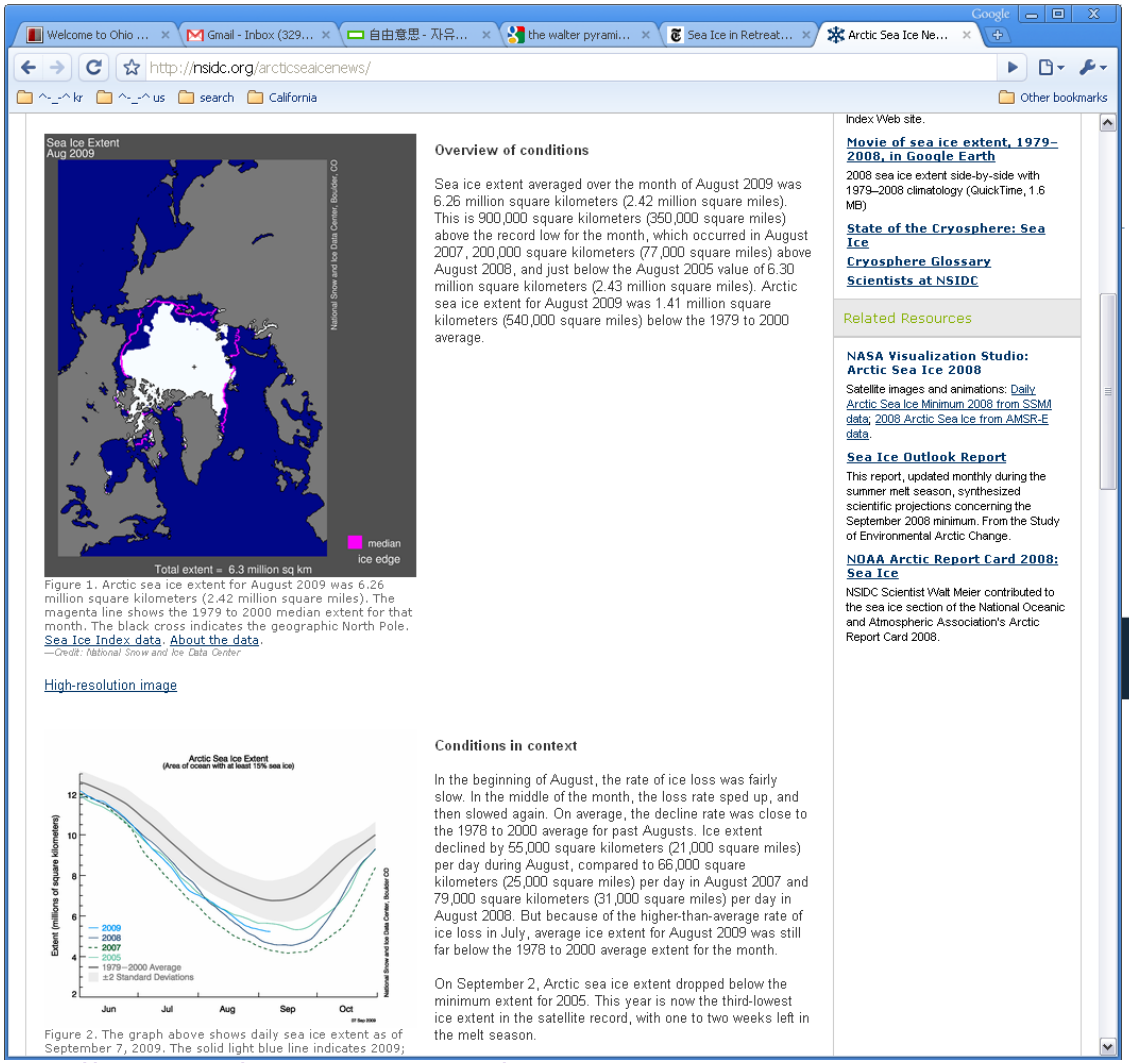
or…

  - Is the world a continuum with measurable attributes at any point such as elevation, moisture, temperature, or vegetation?
    – **The continuous view**

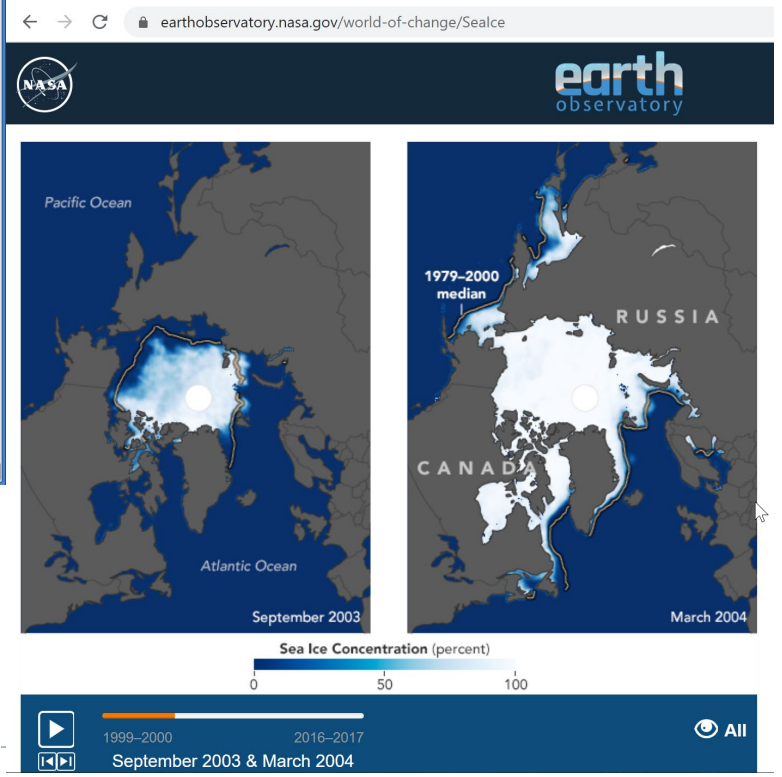
Discrete (object) vs. Continuous (field)

- Two common ways to represent the world digitally:

  Vector (discrete view) **Raster (continuous view)**



http://nsidc.org/arcticseaicenews/

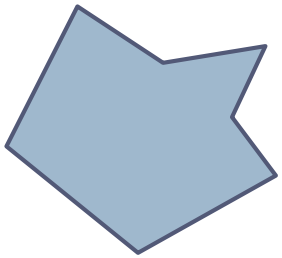


- Q. Discrete? Continuous?

https://earthobservatory.nasa.gov/world-of-change/Sealce

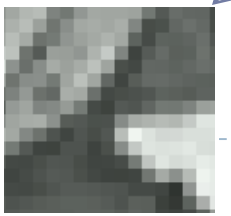
Vector types and objects

- Applies when a phenomenon can be measured at discrete locations
  - Points
    - Cities, trees, houses, archaeological findings…
  - Lines
    - Drainage networks, road networks
  - Areas
    - Census districts, cities (again), school districts, lakes, land cover units



Continuous fields (raster)

- Applies when a phenomenon can be measured at all locations
  - Common in physical geography for air pressure, wind speed, elevation etc.
  - 3D-views common to visualize fields
  - Normally represented on *a grid* – but other representations are used e.g., *triangulated irregular networks (TIN)* (next)



(Figure 9.2 in Lo and Yeung, 2007)

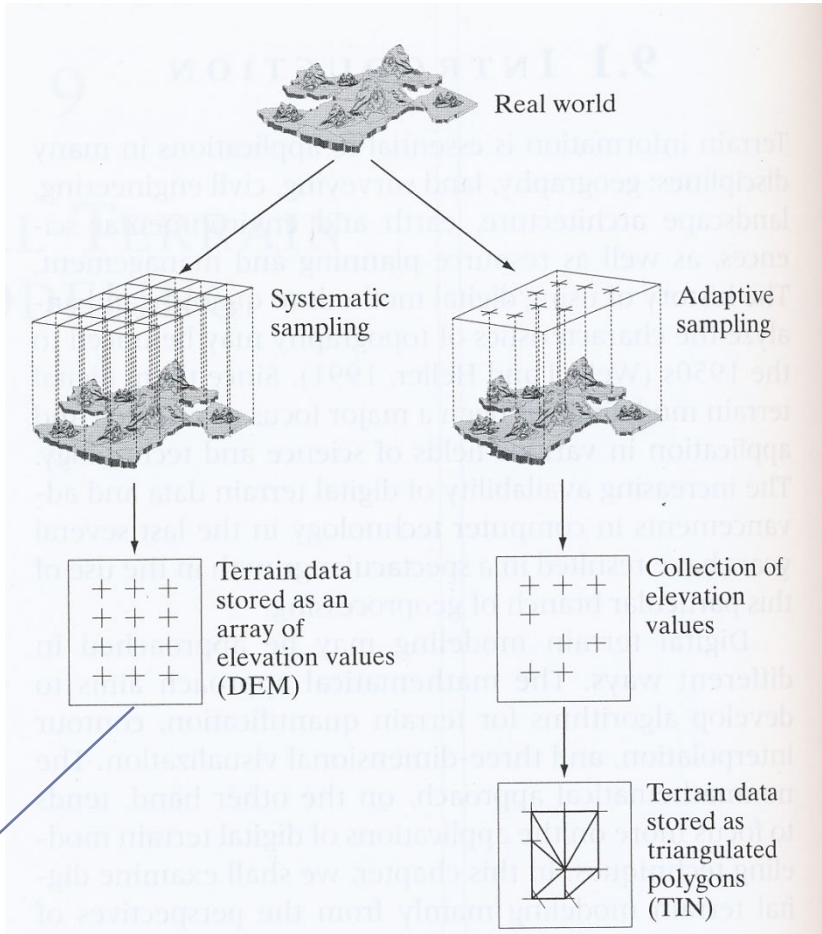


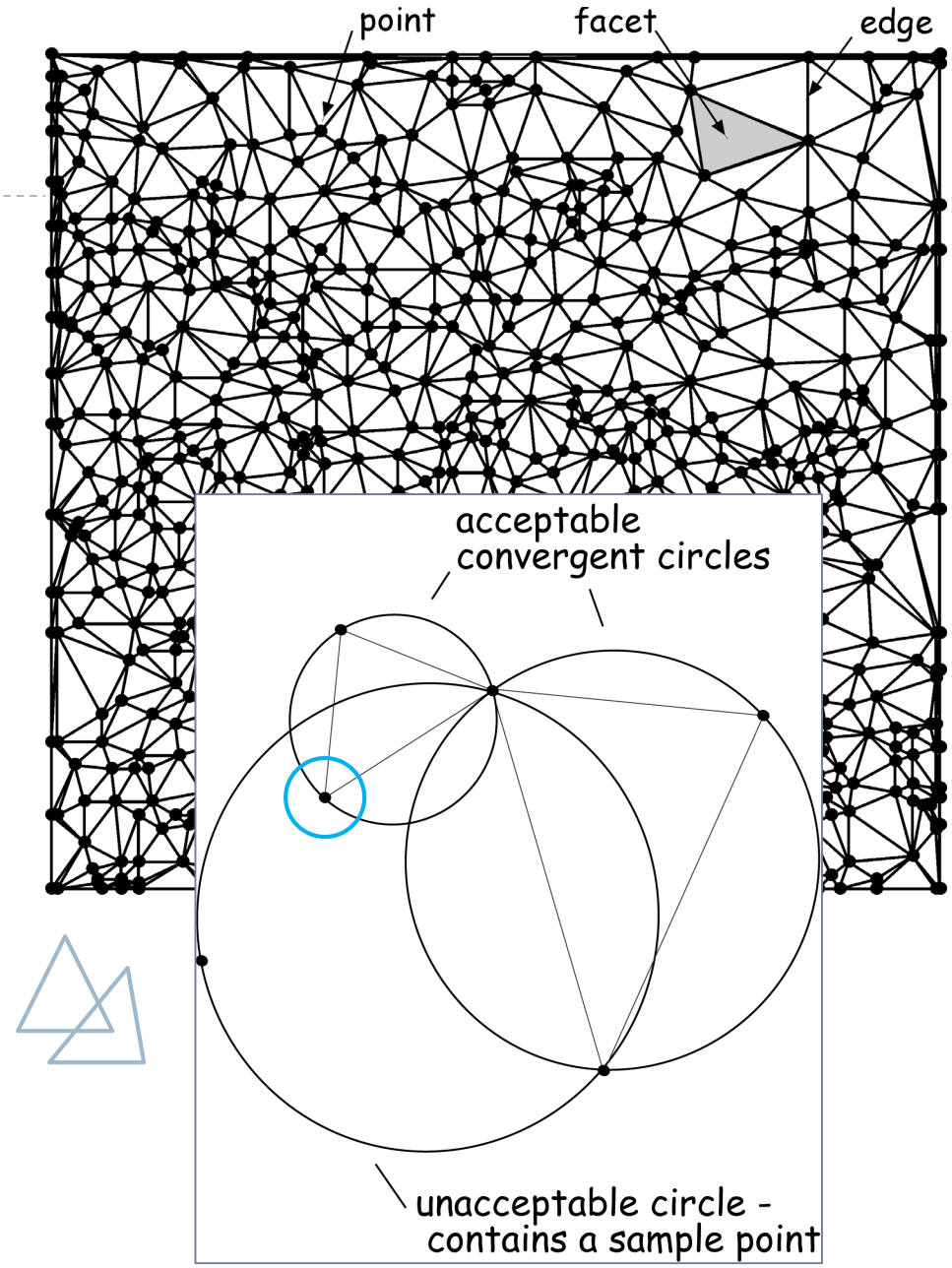
FIGURE 9.2
Approaches to digital terrain data sampling. Terrain data may be sampled either at regularly spaced intervals to form a digital elevation model (DEM) or selectively at salient ground points to form a triangulated irregular network (TIN).

TIN Data Model

- Frequently used for terrain surface modeling
  - Slope, aspect, etc.
- x, y, z coordinates of sample points

→ A connected network of triangles

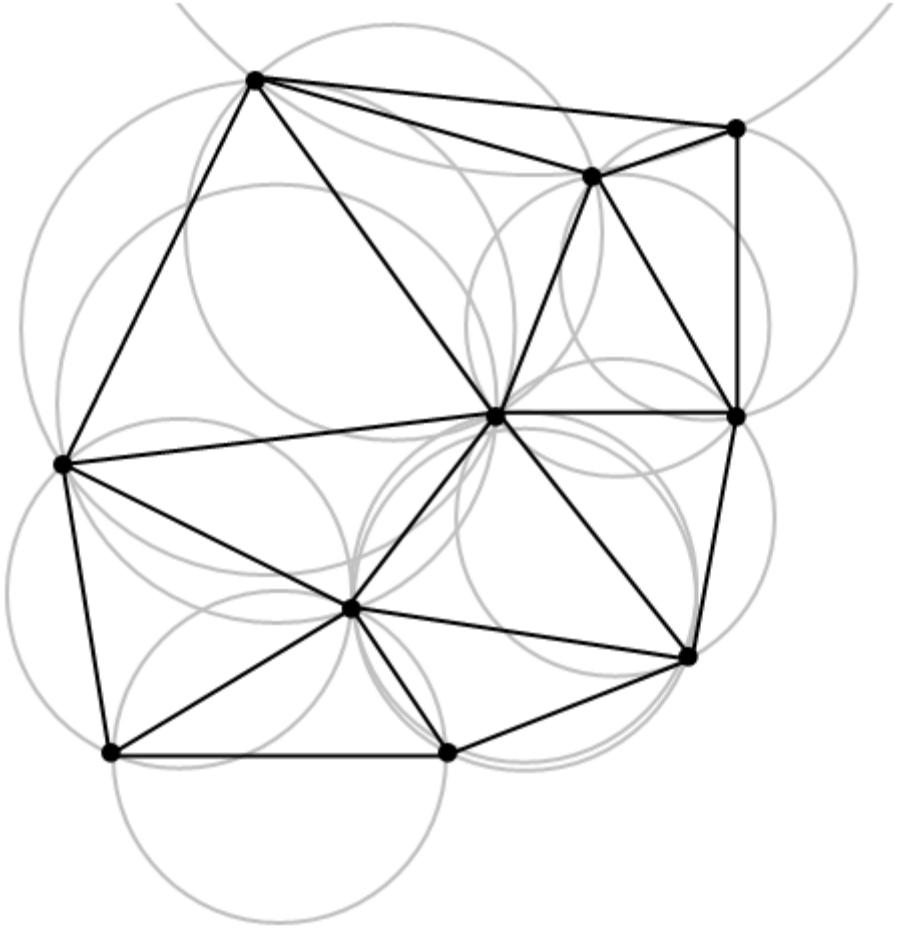
- Delaunay Triangle
  - Created by lines from one triangle that do not cross the lines of another
  - A triangle is drawn only if its convergent circles contains no other sampling points



x

(image source: Bolstad, 2012)

Q. Are they Delaunay Triangles?



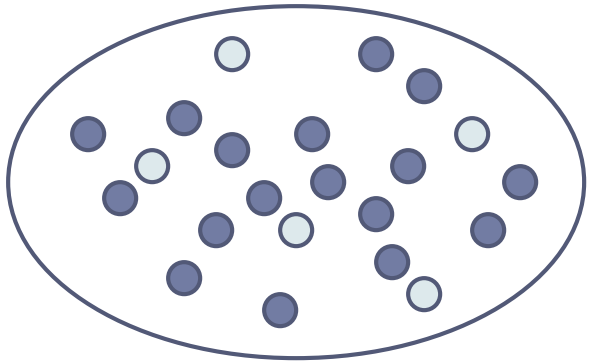
commons.wikimedia.org

Map data acquisition

- Sensor (human – machine or combination)
- Collection protocol
  - Measure X at certain points using regular intervals
    - E.g., field work
  - Identify objects and record locations & attributes
    - E.g., Remote Sensing
- Collection method
  - Field work measurement/observation
    - E.g., GPS
  - Remote sensing – interpretation/processing
    - E.g., Satellite imagery
- End product
  - Paper/digital map
  - GIS database

Samples, population, census…

- The population (or universe) is the total set of elements under examination in a study
- The sample is the group of elements actually studied/measured – a subset of the population
- A census is a survey where the entire population is studied/measured
- Usually, we use a sample to say something about the entire population (inferential statistics)



A lot of reasons for sampling

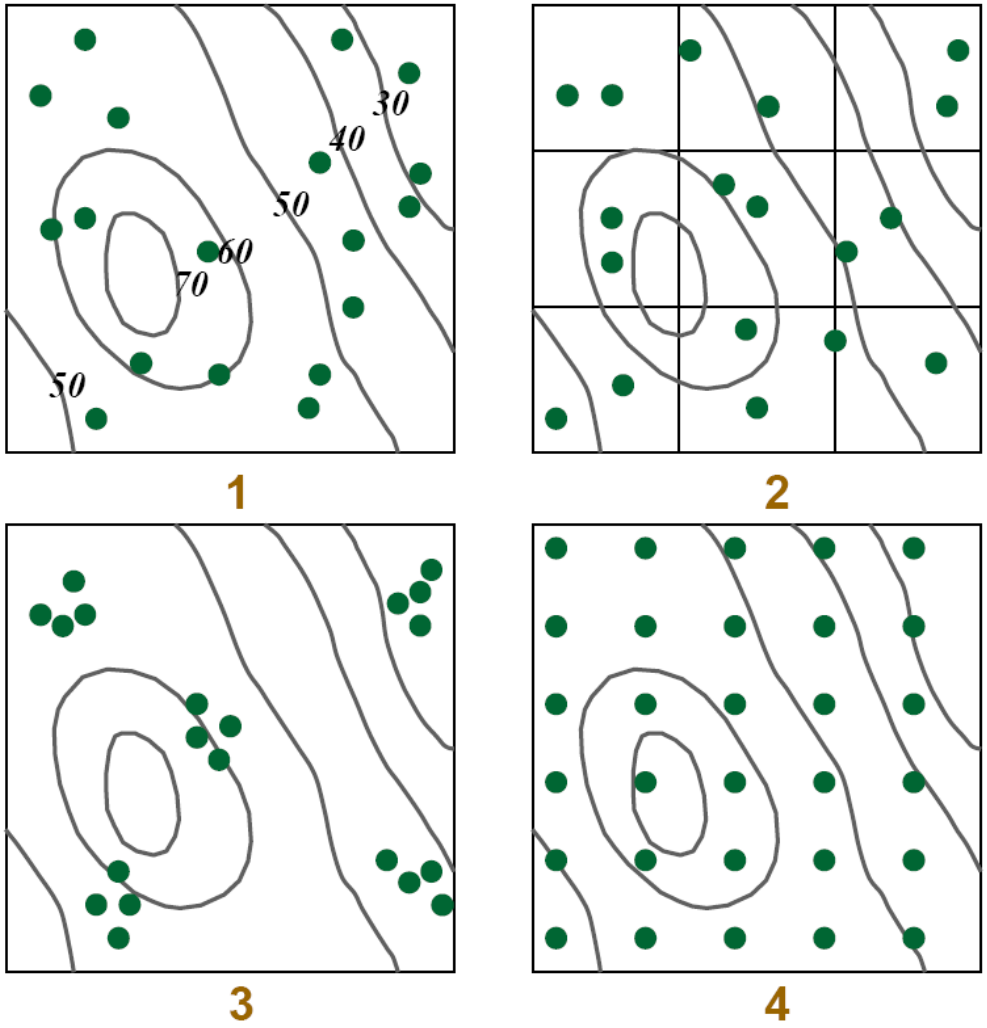
- Time, cost, and effort
- Population (all observations) may be infinite
  - E.g., Temperature, elevation, time
- Population finite but partly inaccessible
  - E.g., Sites with danger
- Population size and survey technique tradeoff
  - E.g., In-depth interviews of individuals
- Often not necessary to make a census
  - Proper samples can be good enough – with no bias

Sauron not available

Some common spatial sampling types

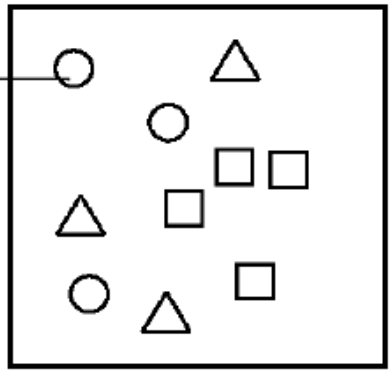
1. Simple random
2. Stratified random
3. Random cluster
4. Systematic random
5. Multistage sampling, combination of 1~4

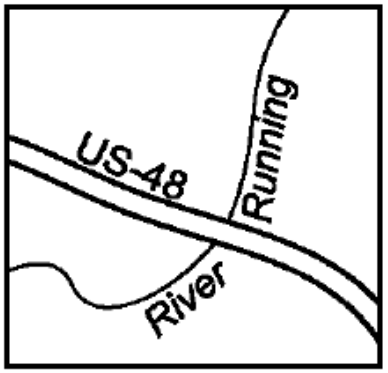
Example: To measure elevation of the area, we pick the green dots for sampling…

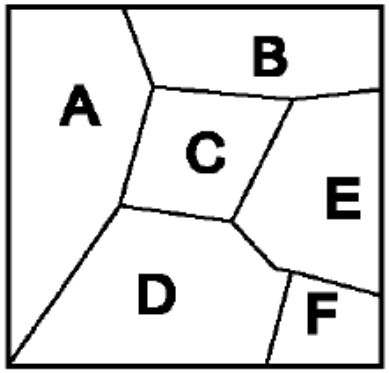


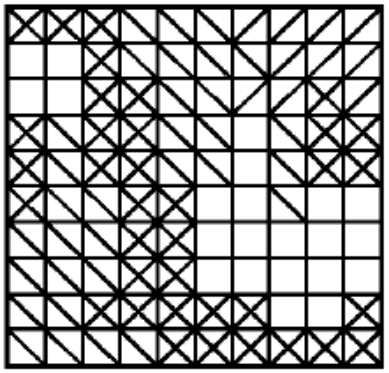
Geographic data

- Typically separated between geometry and attributes with links









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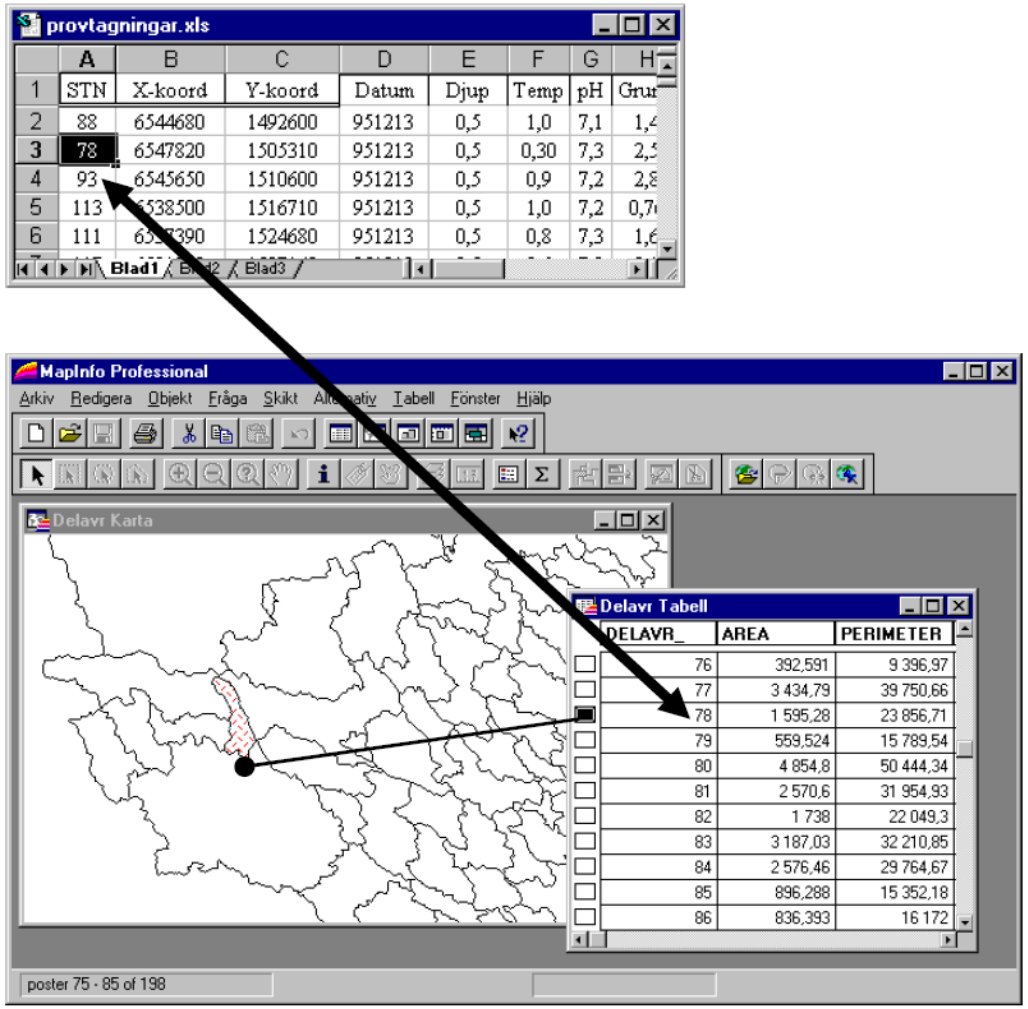
1178	-114.3000	39.0167	0.10	NPS	1989-10-14
55	-114.2000	39.0330	0.00	BLM	1986-08-06

Relations that link to a map

- If links are maintained between spatial data (geometry) and attribute data we get a GIS dataset
- Possible for both raster and vector data-types



Where can I find GIS data?

- U.S. Geological Survey
  - Geology, Hydrology, Vegetation
- U.S. Census Bureau
  - Population, demographics, community statistics
- U.S. Department of Commerce
  - economic, business, international trade information
- U.S. Department of Agriculture
- U.S. Fish and Wildlife Service
- Environmental Protection Agency
- …and a few other sources

Measurement scales

- Nominal
- Ordinal

} *Categorical variables*

- Interval
- Ratio

} *Numerical variables*

- From an analytical point of view, the most useful measurements are numerical, followed by ordinal, then nominal

Nominal data

- Categories with no rank or order

- Examples
  - male/female
  - yes/no/don't know
  - sweet/non-sweet
  - deciduous/coniferous
  - oak/elm/maple
  - land cover/geology
  - hobbit/elf/human/dwarf/ogre/troll

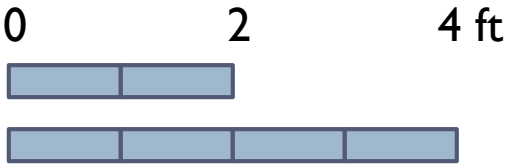
Ordinal data

- Categories where there is a meaningful way of ranking them, non-numerically

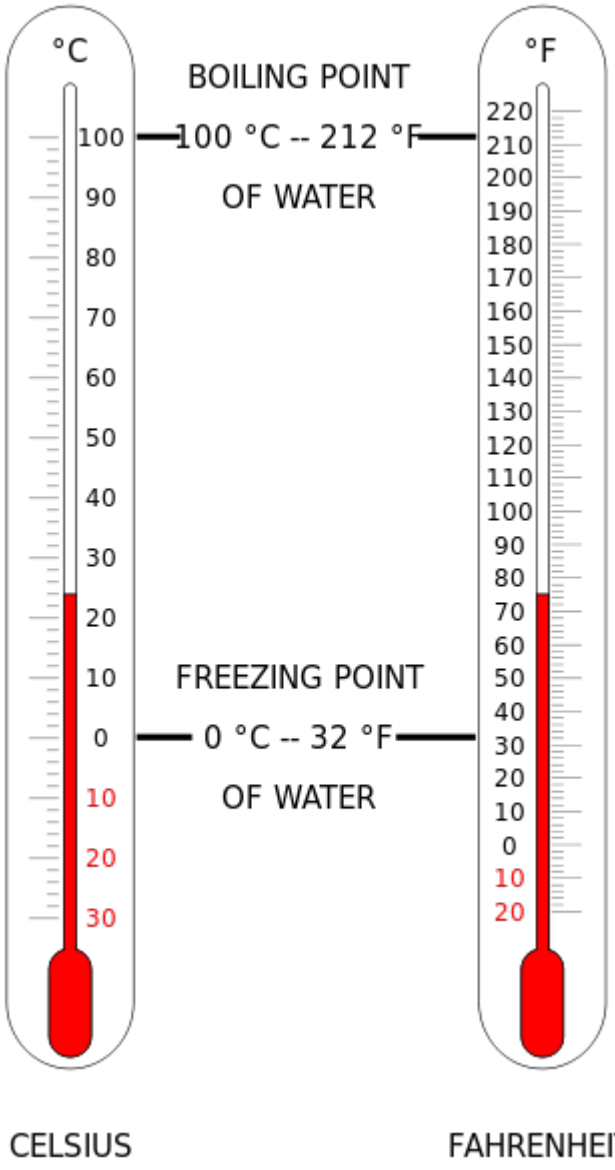
- Examples
  - Education: primary/secondary/college
  - Survey: agree/neutral/disagree
  - Age classes: young/mid-age/old
  - Vegetation density: dense/sparse/open
  - Evaluation: not likely, somewhat likely, likely
  - Height: troll/elf/human/hobbit

Numeric data

- Interval: where numbers are associated with data and conceptual distances between them are meaningful, zero is arbitrary
  - E.g., temperature (0 °Celsius = -273.15 Kelvin)
- Ratio: where ratios are meaningful, *or, put* another way, zero is *not* arbitrary but absolute
  - E.g., length: 2ft & 4ft (Meters or Feet?)



- Measurement unit can be arbitrary: ft,. mi., in., m, km, cm, …



http://en.wikipedia.org/wiki/File:Thermometer_CF.svg

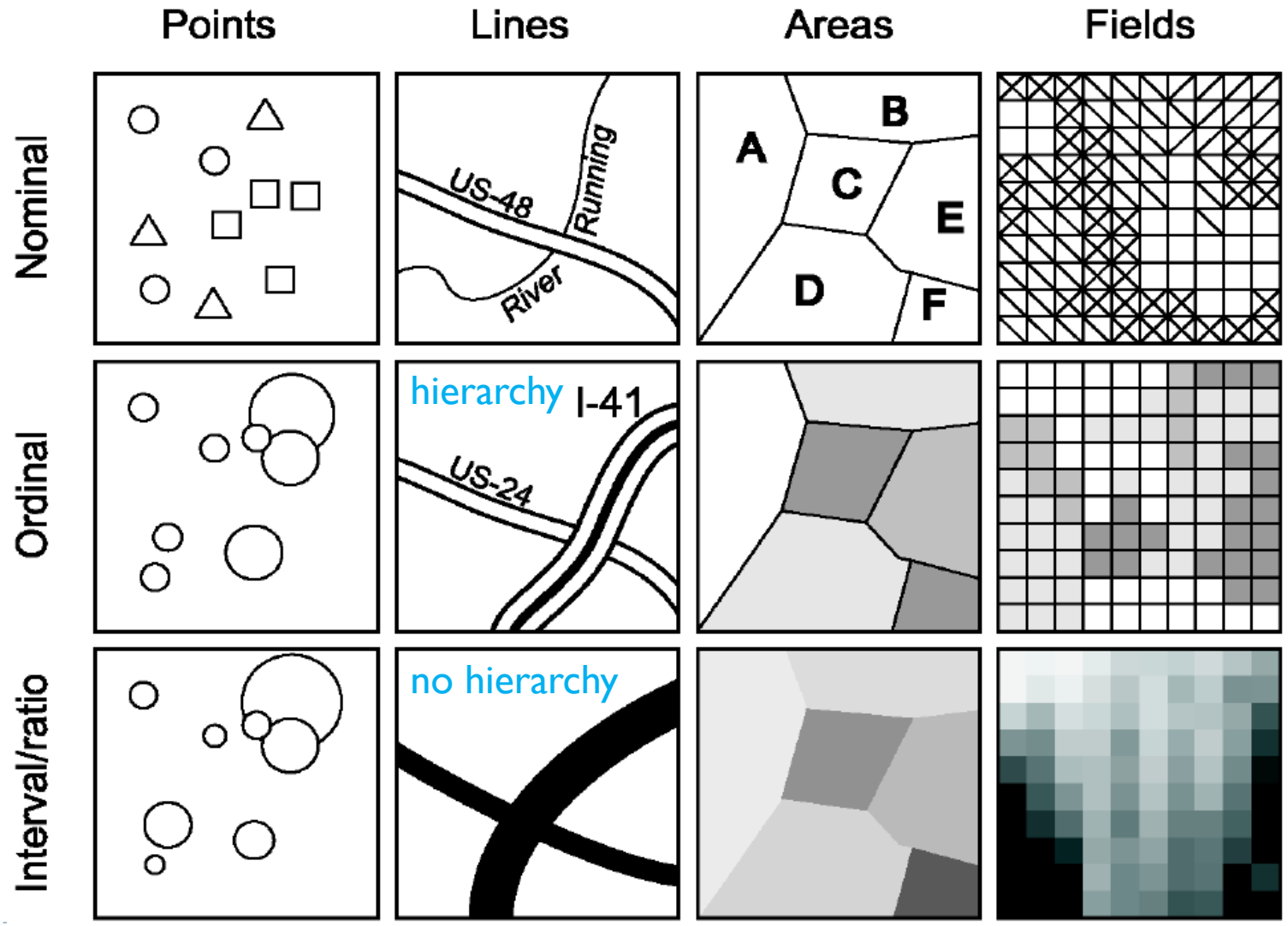
Criticism

- This scheme was developed by Stevens in 1946, and has since been widely taught…
- It has been criticized, however.
  - What about…
    - Angles (Angle *x is as far from 0° as 360°)*
    - Vectors ([4,3] has same magnitude as [-3,4])
    - Counts ("11.3 persons" doesn't make sense……..does it???)
    - Percentages (typically a bound interval [0,100])
    - Probabilities (a bound interval [0,1])
    - Fuzzy ordinal categories (how cool is "cool"?)
- Again, the important thing is not to get too hung up on using the scheme, but knowing what to do with your data

Exercise

- Make a group of 3-5 people
- Find 2 examples of nominal, ordinal, interval, and ratio type data
- Share your group's findings

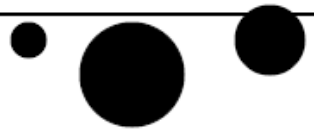
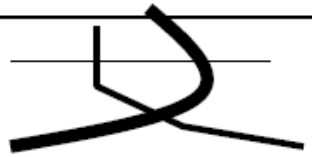
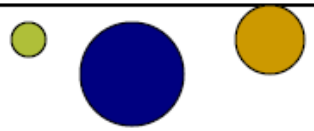
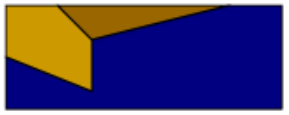
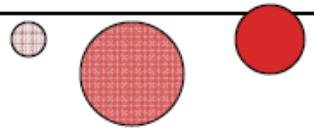
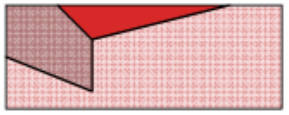
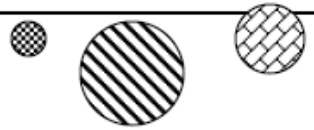
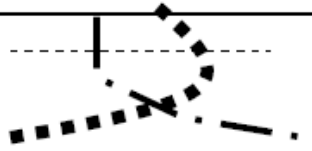
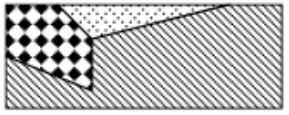
Dimensionality and measurement types combine & require specific symbolizations



(More diverse than ordinal)

Source: O'Sullivan and Unwin, 2003

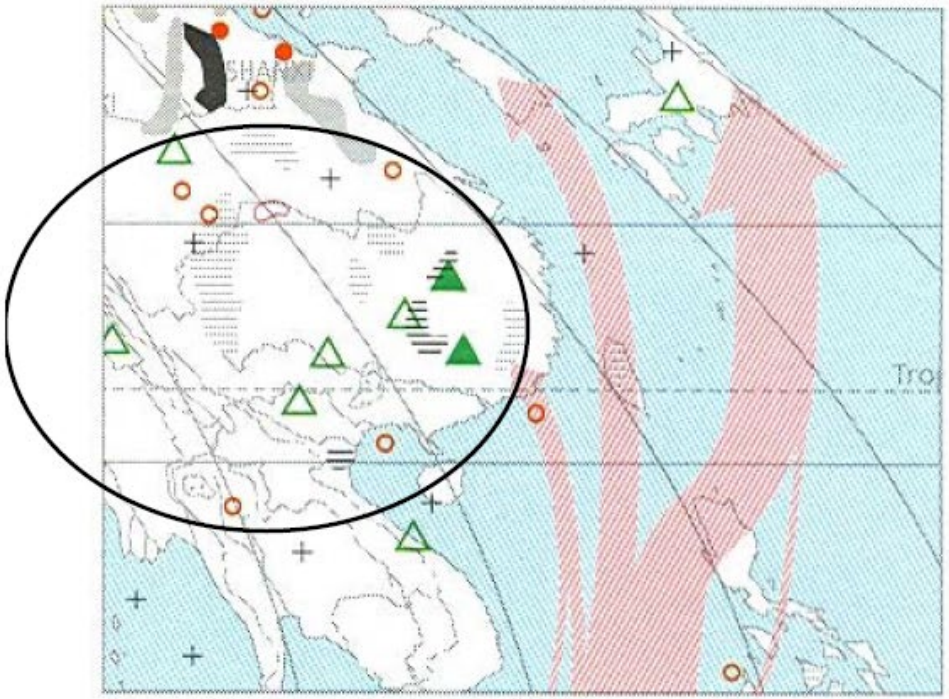
Symbolization – the visual variables (see also Color plates 5.1 & 5.2)

	Points	Lines	Areas	Best to show
Shape		Possible but too weird to show	cartogram	Qualitative differences
Size			cartogram	Quantitative differences
Color hue				Qualitative differences
Color lightness				Quantitative differences
Color saturation				Quant. & qual. differences
Texture				Qualitative differences

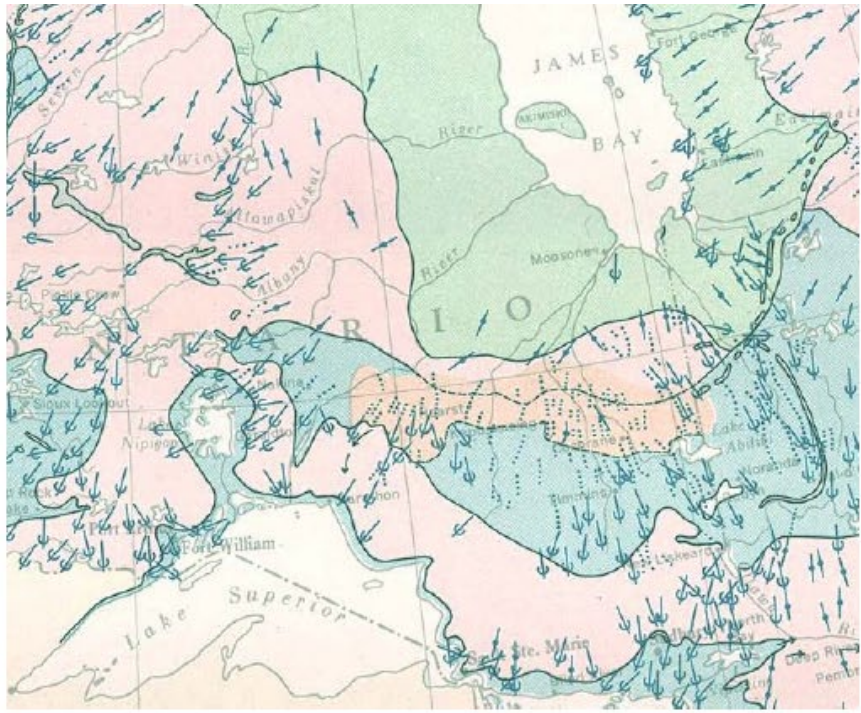
Source: Krygier & Woods

Shape

	Points	Lines	Areas	Best to show
Shape		Possible but too weird to show	cartogram	Qualitative differences

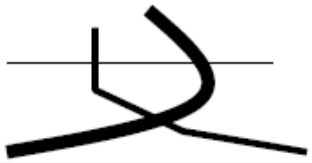


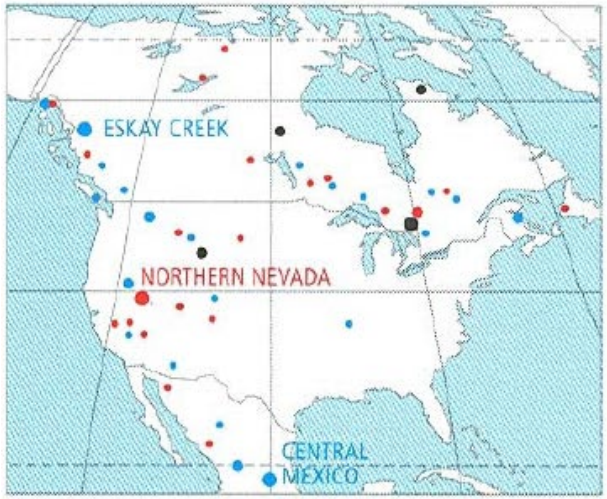
Flow line map: Detail of Mineral Fuels (pp. 58-59) Source: Goode's Atlas



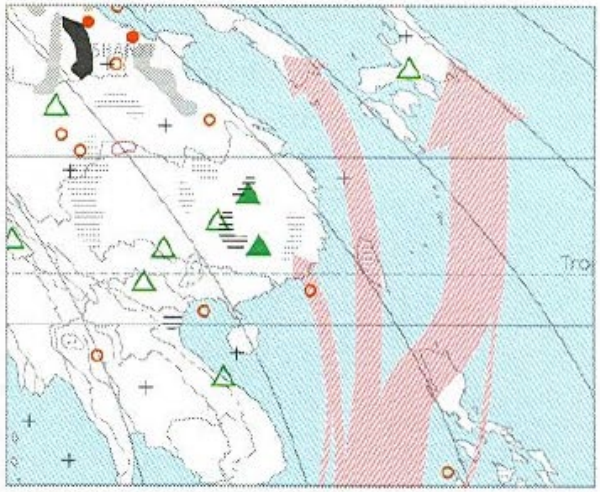
Source: Natural Resources Canada

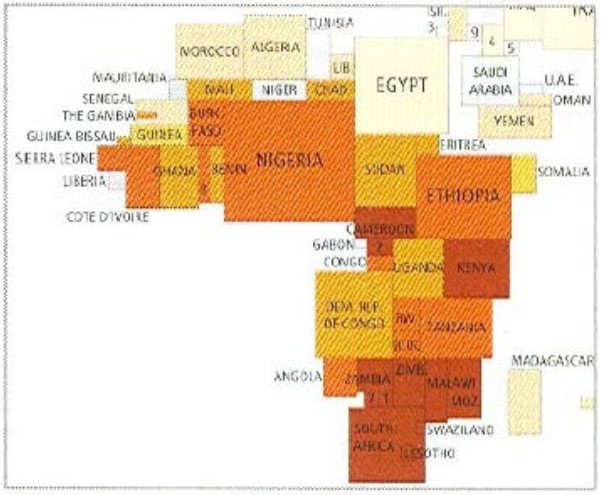
Size

	Points	Lines	Areas	Best to show
Size			cartogram	Quantitative differences



Point symbol map: Detail of Precious Metals (p. 55)

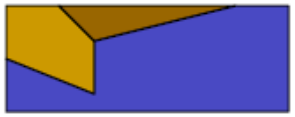

Flow line map: Detail of Mineral Fuels (pp. 58-59)

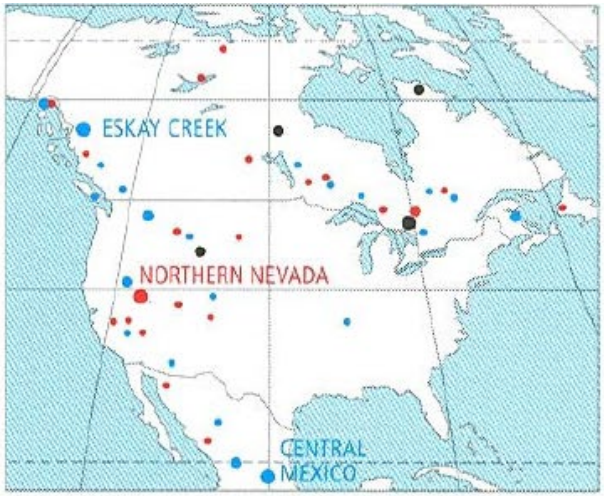


Cartogram: Detail of HIV Infection (p. 37)

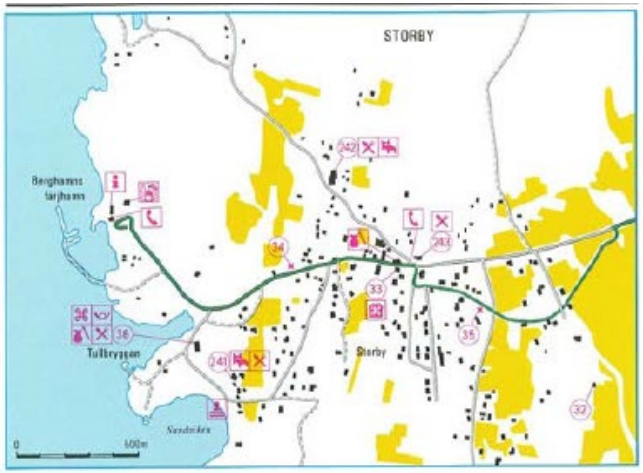
Source: Goode's Atlas

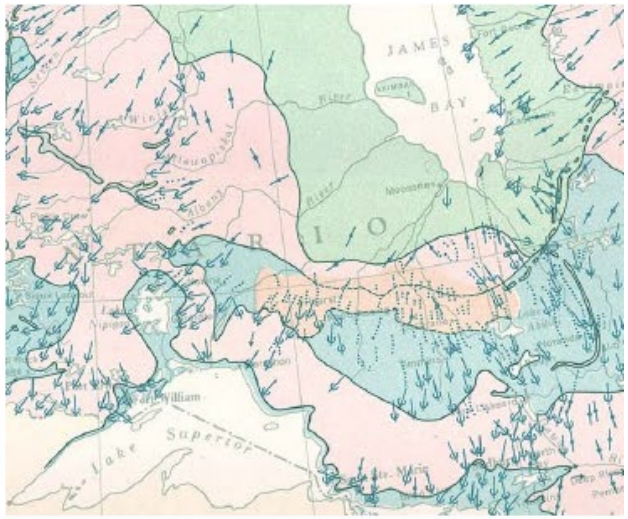
Color hue

	Points	Lines	Areas	Best to show
Color hue				Qualitative differences



Point symbol map: Detail of Precious Metals (p. 55)

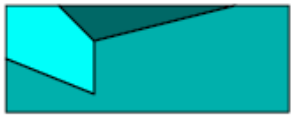




Source: Natural Resources Canada

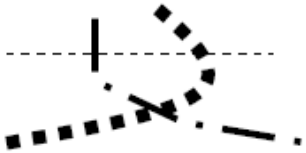
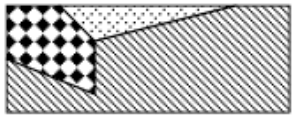
Source: Goode's Atlas

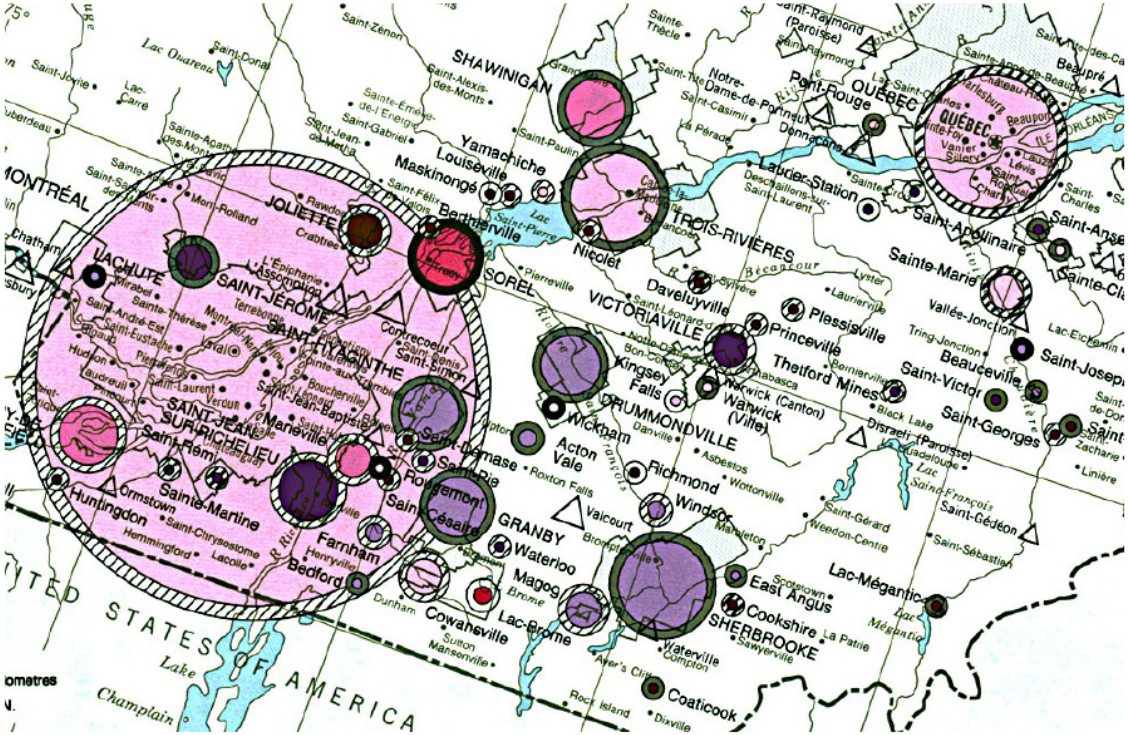
Color lightness

	Points	Lines	Areas	Best to show
Color lightness				Quantitative differences

California Physical Map - California Relief Map:

Texture

	Points	Lines	Areas	Best to show
Texture				Qualitative differences



Q. What do you think? Good texture or not? Why?

Source: Natural Resources Canada

Questions?

- For next time…
  - Reading: Ch. 1
- Worksheet 1

FYI – Certificate Programs in Geography

- Certificate in GIS
  - http://www.cla.csulb.edu/departments/geography/geographic-information-sciences/
- Certificate in Urban Studies
  - http://www.cla.csulb.edu/departments/geography/urban-studies-department-of-geography-csulb/